

Pathfinder Airborne Radar Ice Sounder (PARIS)

Arctic 2009 Overview (Ice Bridge)

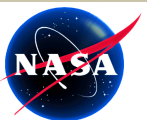
*NASA IIP Final Review
Johns Hopkins University,
Applied Physics Laboratory*

**NASA award #: IIP-04-0097
Janice L. Buckner, NASA/ESTO**

27 January 2010

APL

The Johns Hopkins University
APPLIED PHYSICS LABORATORY





PI: *R. K. Raney*

Pathfinder Advanced Radar Ice Sounder

(PARIS)

Objective: *To provide the first demonstration of radar sounding of ice sheet bottom topography from a high-altitude platform*

Summary

Design and build a 150 MHz radar for the NASA P-3 aircraft

Data collections (~ 10 TB) over Greenland and Antarctica

Innovative algorithm development

Design (435 MHz) suited to a UAV

Accomplishments¹

Ice depths in excess of 3 km

Along-track beam sharpening

Cross-track clutter suppression

Autonomous bed-rock retrievals

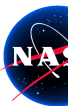
US industry interest in UAV design

11 publications (including 1 patent)

¹(2005-2009)

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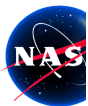
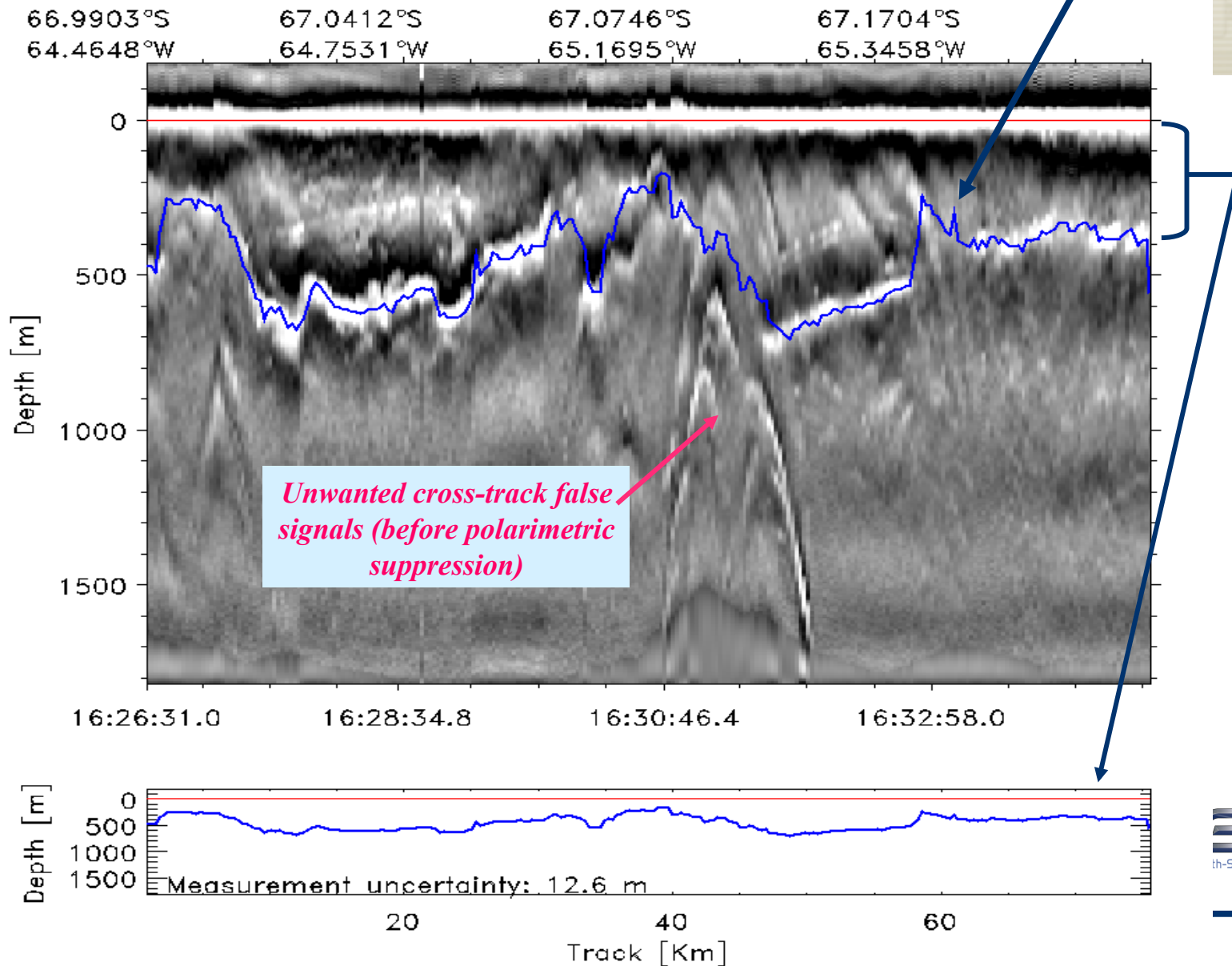
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Innovative Retrieval Algorithm

Automated “bedrock tracker”

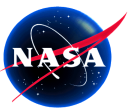


New PARIS Antenna

From
this



To
this



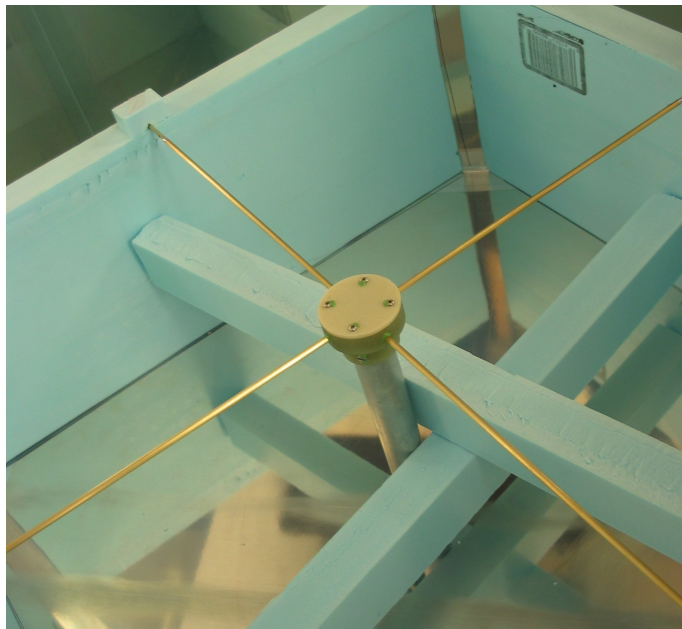
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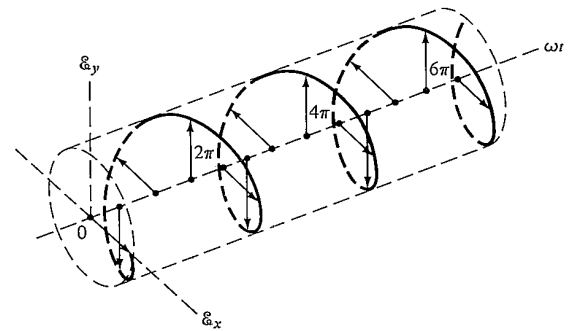
PARIS Annual Review

Turnstile PARIS Antenna

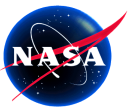
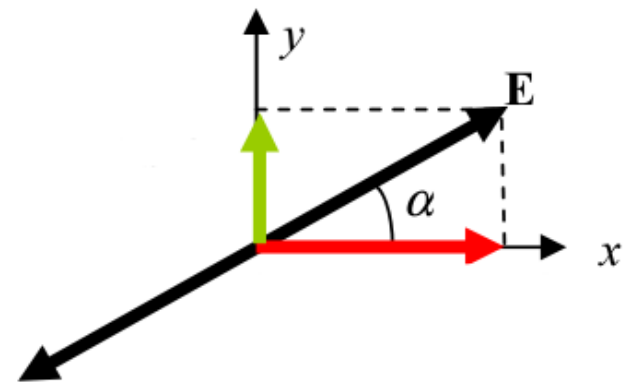
Orthogonal, linearly-polarized
antennas: (hybrid-polarimetric)



Radiate circular
polarization on
transmit:

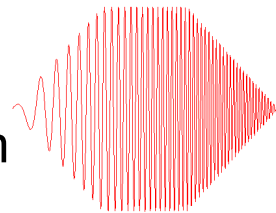


But receive
both linear
components
on receive:

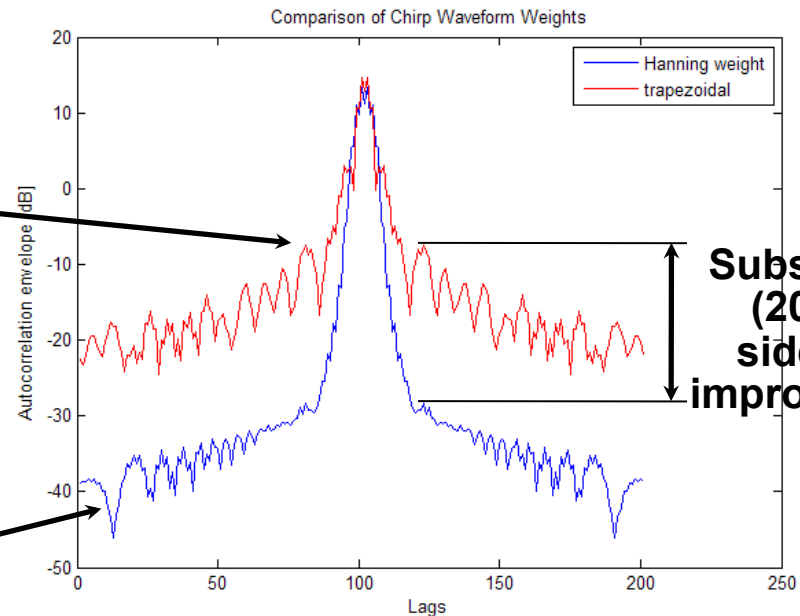
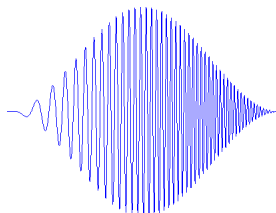


PARIS 2 Hardware Design: Planned Waveform Improvement

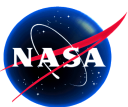
Original PARIS
transmit waveform



Optimal transmit
waveform



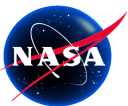
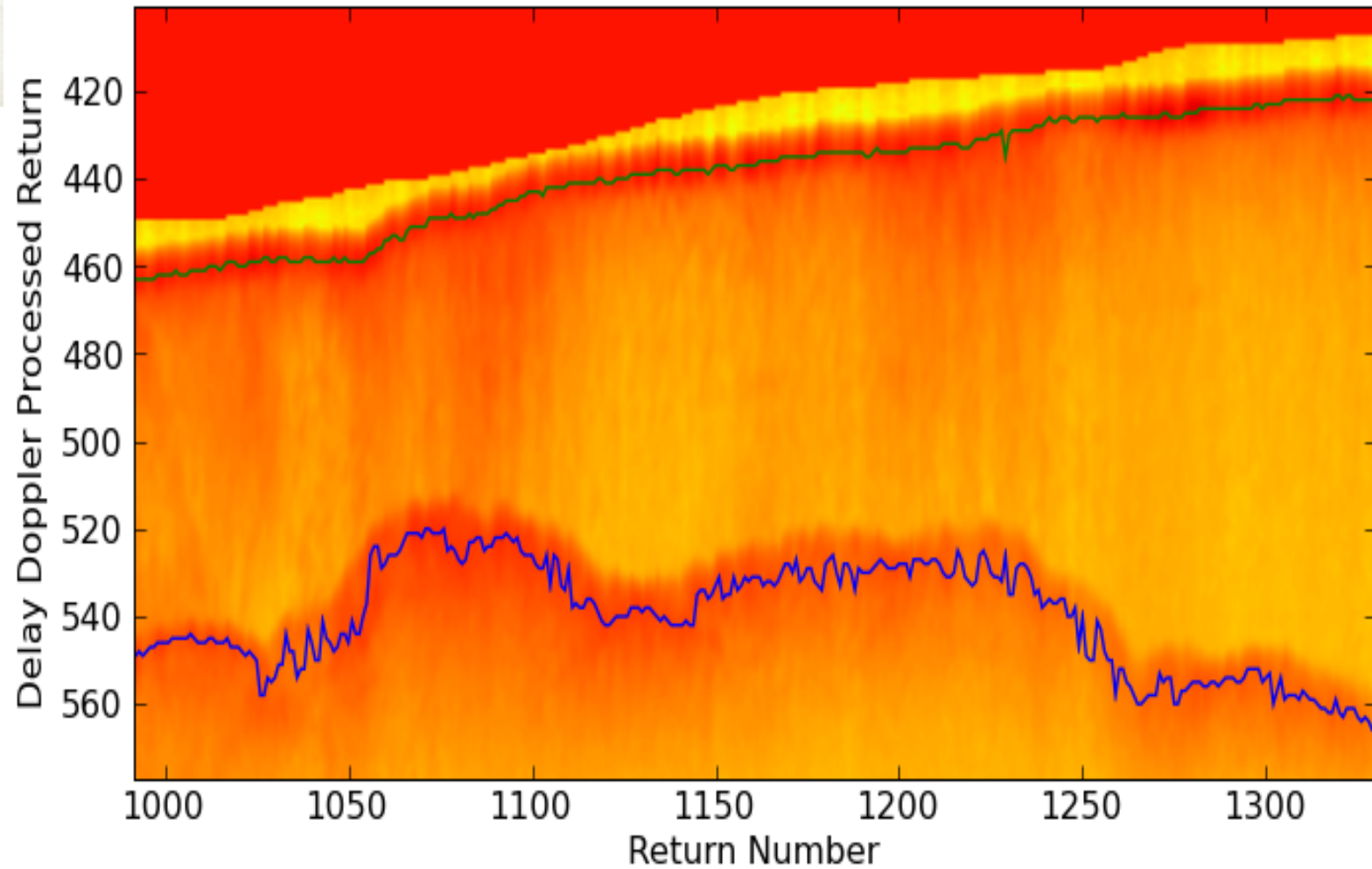
- ***Optimum chirp waveform improves signal-to-noise ratio, minimizes remote spurs***
- ***Offers the additional benefit of compensating for non-linearities in transmitter***



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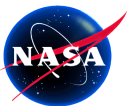
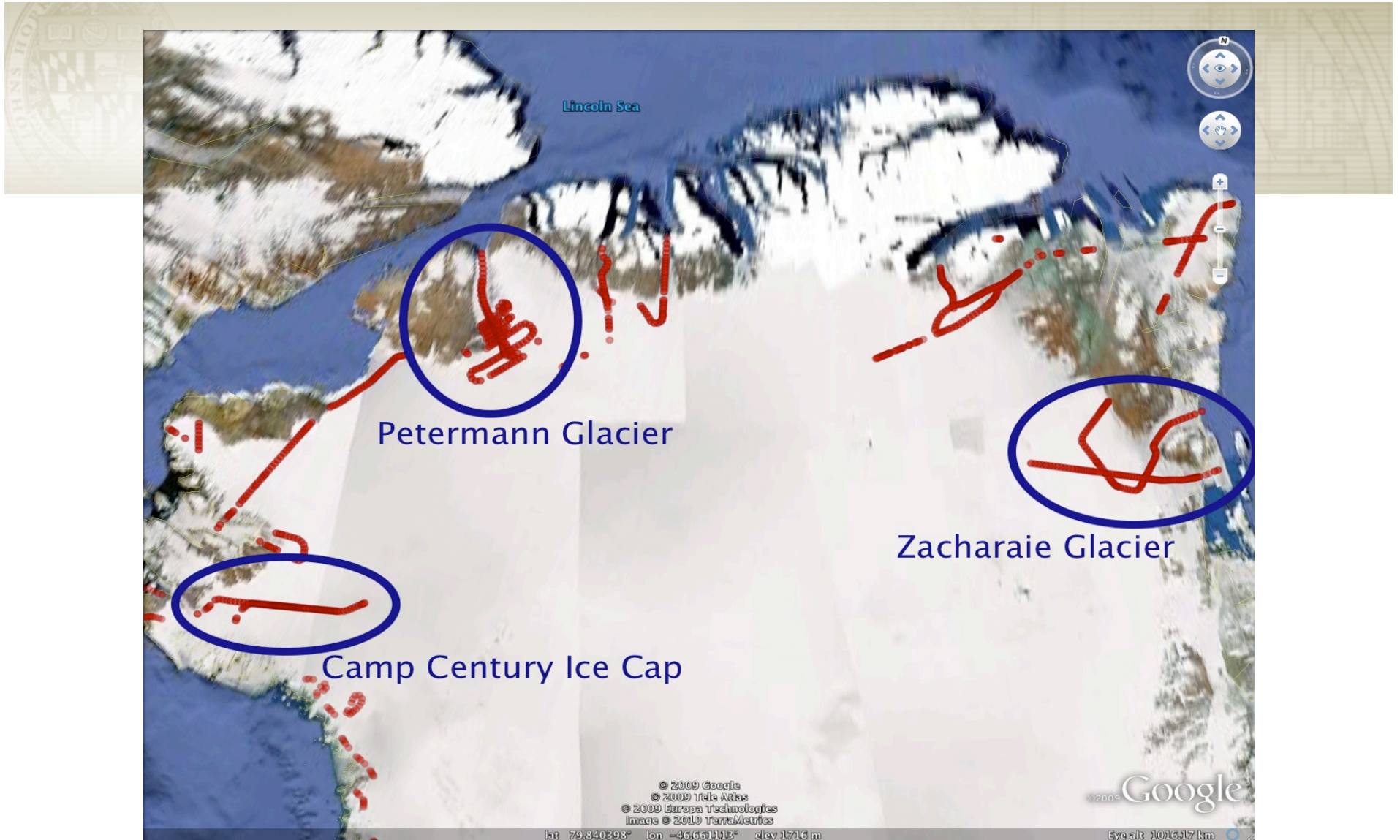
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Modified Surface/Bottom

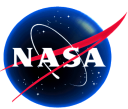
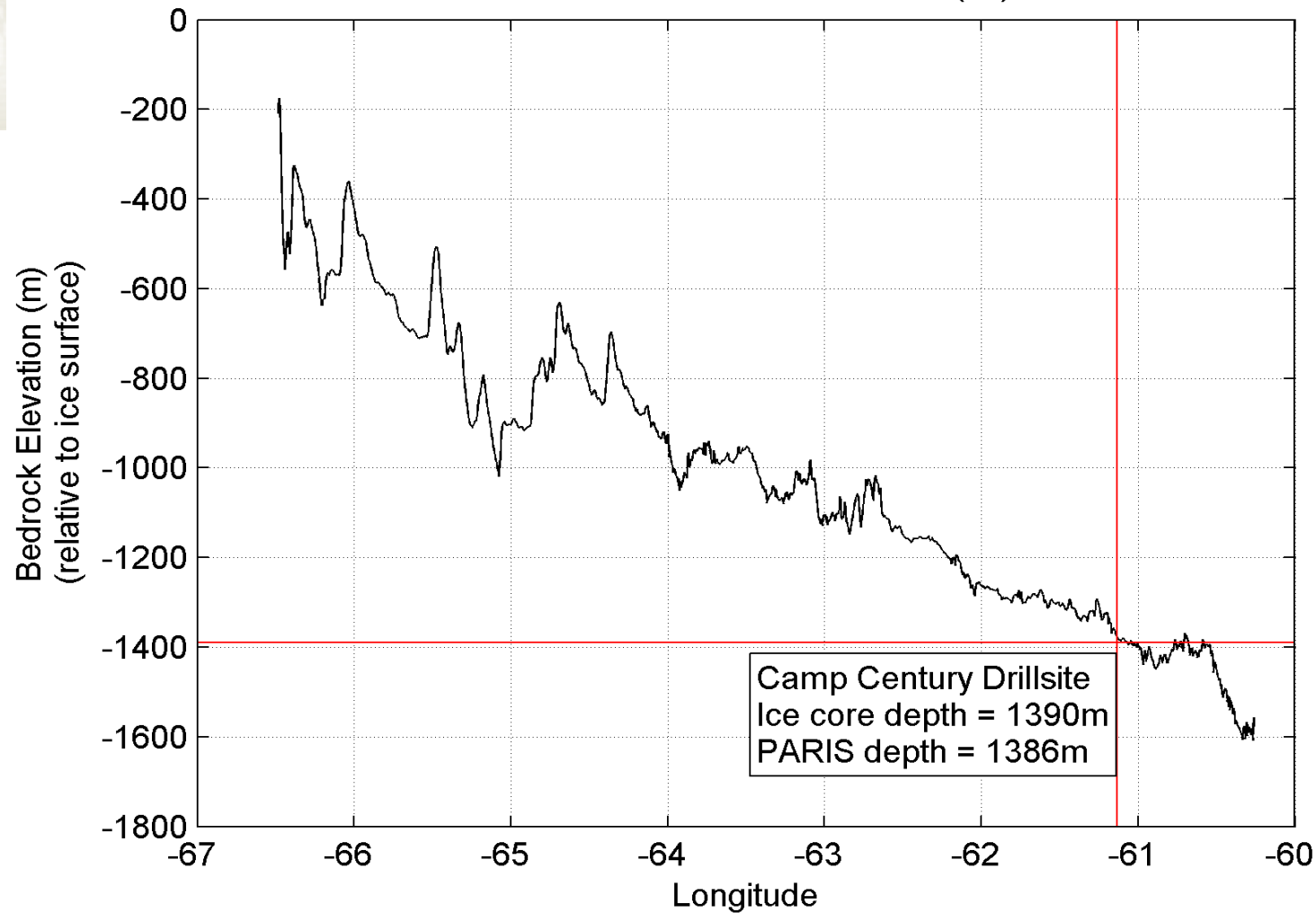


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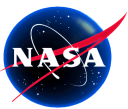
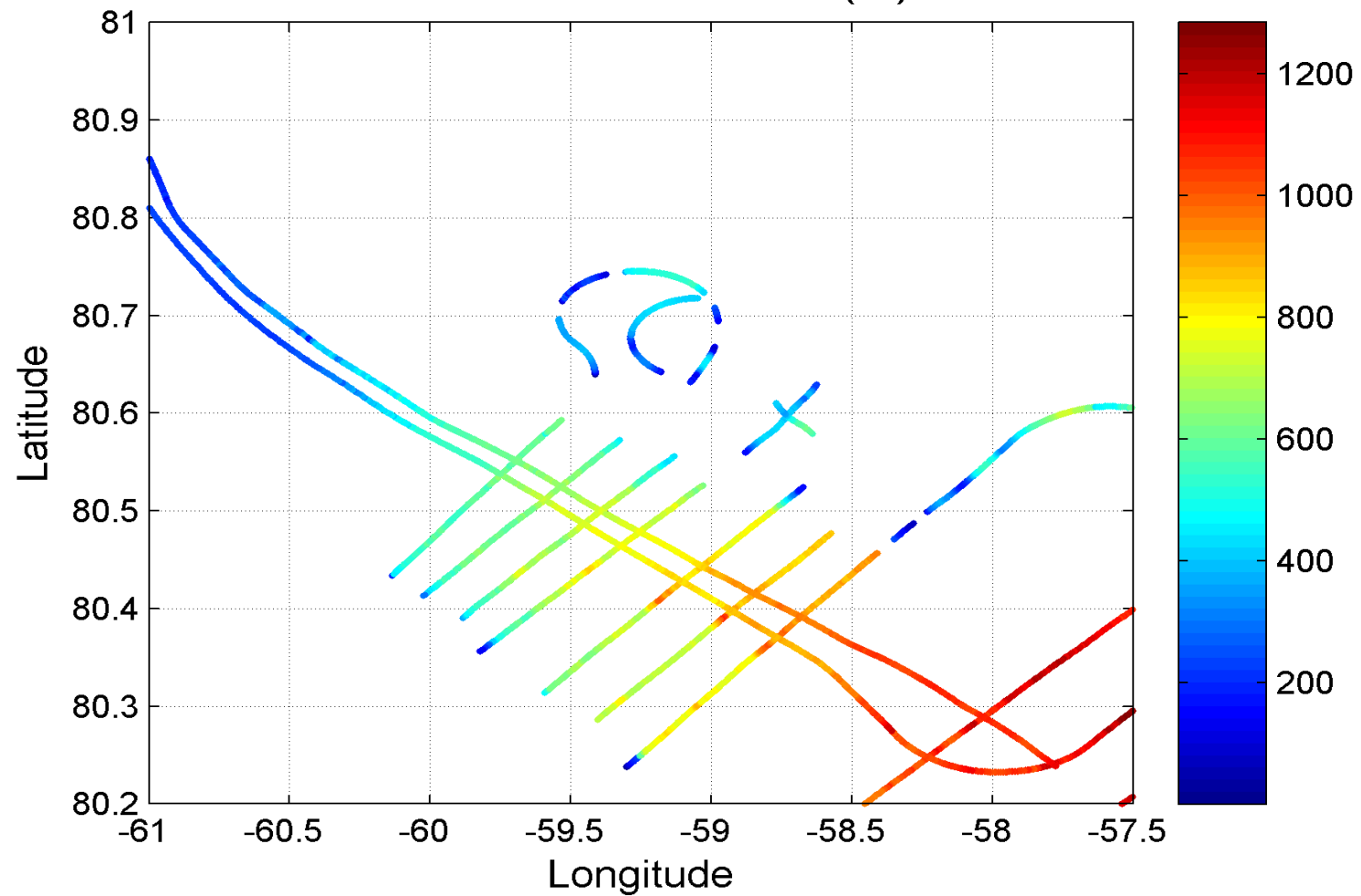
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Camp Century Line, April 20, 2009 PARIS Bedrock Elevation (m)



Petermann Glacier, 04/22/2009 PARIS Ice Thickness (m)

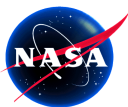


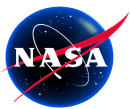




Greenland/Arctic Sea Ice Campaign 2009

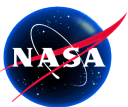
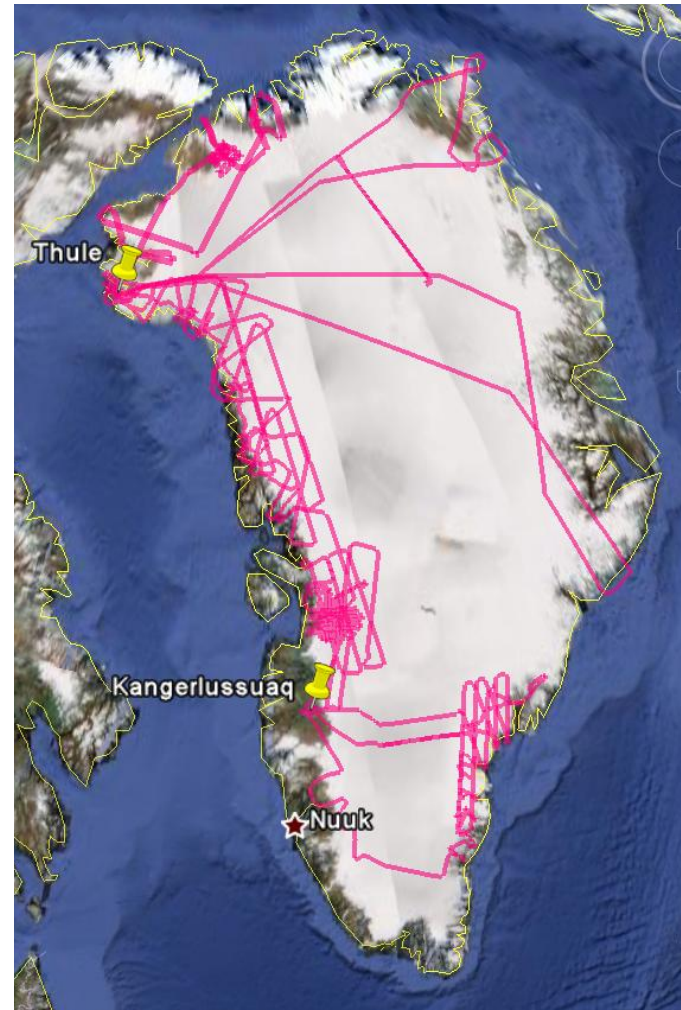
Date	Flight #	hours	Target	ATM T2	ICESSN	ATM T3	ICESSN	ATM QTY	CAMBOT	CAMBOT QTY	JH-APL-PAF	PARIS QTY
3/31/09	718	8.1	Arctic Sea Ice	34.3 Gb	X	34.3 Gb		68.6 Gb	X	6.5 Gb	X	5.7 Gb
4/1/09	719	7.7	E. Greenland	35.5 Gb	X	36.4 Gb		71.9 GB	X	6.5 Gb	X	14.3 Gb
4/2/09	720	8.2	Cross Arctic Sea Ice	41.0 Gb	X	40.8 Gb		81.8 Gb	X	8.2 Gb		
4/5/09	721	8.7	Cross Arctic Sea Ice	43.9 Gb	X	43.8 Gb		87.7 Gb	X	2.1 Gb		
4/6/09	722	7.7	NW Greenland Glaciers	49.5 Gb	X	48.3 Gb		97.8 Gb	X	9.8 Gb	X	23.8 Gb
4/17/09	730	7.7	NW Greenland Glaciers	57.9 Gb	X	30.6 Gb		88.5 Gb	X	10.8 Gb	X	57.5 Gb
4/20/09	731	9.3	NE Greenland	68.7 Gb	X	41.1 Gb		109.8 Gb	X	12.7 Gb	X	29.2 Gb
4/21/09	732	7.7	Sea ice-envisat overflight NOAA	39.8 Gb	X	23.5 Gb		63.3 GB	X	9.7 Gb		
4/22/09	733	8.0	NW Greenland Glaciers	62.5 Gb	X	36.3 Gb		98.8 Gb	X	10.3 Gb	X	32.2 Gb
4/23/09	734	7.9	East Central Greenland	59.7 Gb	X	35.4 Gb		95.1 Gb	X	9.9 Gb	X	8.3 Gb
4/24/09	735	7.8	Eastern Greenland	60.1 Gb	X	36.0 Gb		96.1 Gb	X	10.0 Gb	X	5.8 Gb
4/25/09	736	6.7	Sea ice- Greenarc overflight- NOAA	40.5 Gb	X	23.8 Gb		64.3 Gb	X	10.4 Gb		
4/27/09	737	7.5	W. Greenland/Jacobshaven	55.4 Gb	X	33.3 Gb		88.7 Gb	X	7.9 Gb	X	29.1 Gb
4/28/09	738	7.4	Jacobshaven	55.3 Gb	X	34.1 Gb		89.4 Gb	X	10.2 Gb	X	20.1 Gb
5/1/09	746	7.3	E. Greenland	50.0 Gb	X	33.0 Gb		83.0 Gb	X	9.5 Gb	X	6.1 Gb
5/2/09	747	6.4	S. Greenland	44.5 Gb	X	26.9 Gb		71.4 Gb	X	6.8 Gb	X	27.7 Gb
5/5/09	757	4.1	W. Central Greenland	29.3 Gb	X	17.6 Gb		46.9 Gb	X	5.0 Gb		





Ice Bridge 2009: PARIS Tracks Flown

- Mission was complex, field duration 36 days
- PARIS was operated during all ATM (low-altitude) flights
- ~7 Tb of PARIS data were collected over 13 days
- Data were acquired over the Greenland summit, marginal glaciers, and multi-year ice in the Arctic basin and the Greenland Sea

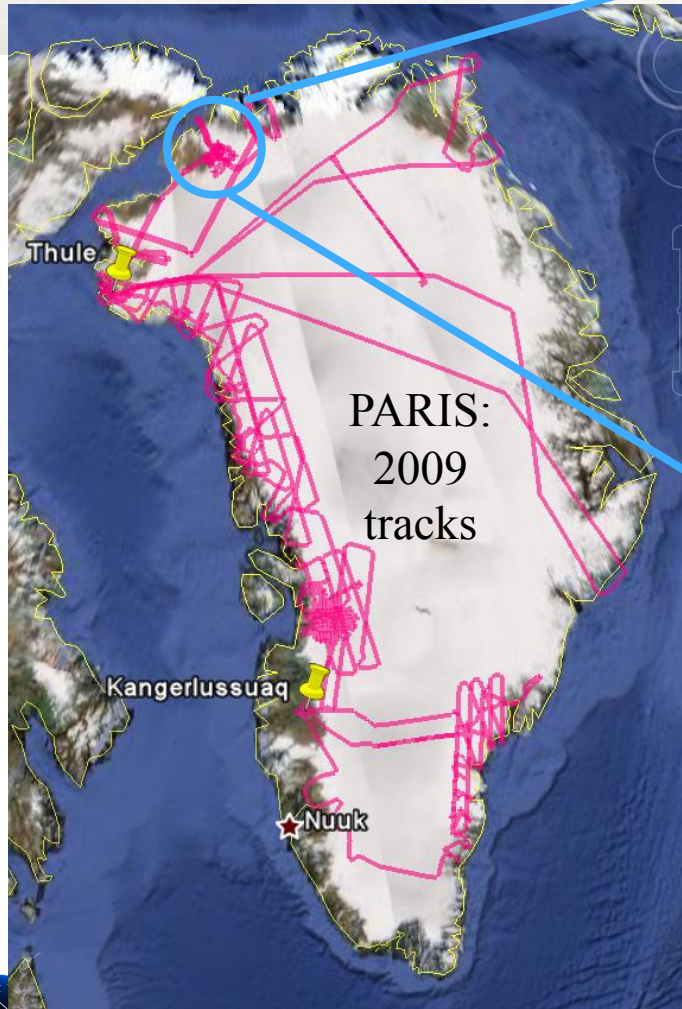


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Water at Base of Outlet Glacier



Basal water



accelerating glacier

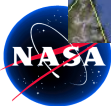


sea level rise

Petermann
Glacier

“Nose” of
glacier

Seawater
intrusions



PARIS: Inside the P-3



PARIS Radar in Operation

